Preprint
UCRL-JC-150921

Diffraction Limited Focal Spots for Off-Thermal Equilibrium 100-TW Nd: Glass Laser Chain using a Dielectric Coated Deformable Mirror

B. Wattellier, J. Fuchs, J. P. Zou, K. Abdeli, J.-C. Chanteloup, K. Haefner

U.S. Department of Energy

Lawrence Livermore National Laboratory

This article was submitted to
2003 Conference on Lasers and Electro-Optics Quantum Electronics and Laser Science Conference, Baltimore, MD, June 1-6, 2003

November 18, 2002

This work was performed under the auspices of the United States Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

Diffraction limited focal spots for off-thermal equilibrium 100-TW Nd:Glass laser chain using a dielectric coated deformable mirror

B. Wattellier
Lawrence Livermore National Laboratory, Laser Science and Technology, 7000 East Avenue, L-490, Livermore, CA 94550 USA
wattellier1@llnl.gov

J. Fuchs
General Atomics, Fusion Group, 3550 General Atomics Court, San Diego, CA 92121-1122

J. P. Zou, K. Abdeli, J.-C. Chanteloup
Laboratoire pour l'Utilisation des Lasers Intenses, Ecole Polytechnique, 91128 Palaiseau CEDEX, France

K. Haefner
Gesellschaft fur SchwerIonen, Darmstadt, Germany

Abstract: We demonstrate the use of a dielectric-coated deformable mirror to correct LULI 100-TW Nd:Glass facility spatial aberrations. Almost diffraction limited foci have been obtained even when the laser chain amplifiers were highly off thermal equilibrium.

OCIS Codes:

High power CPA laser chains, such as the LULI (Laboratoire pour l'Utilisation des Lasers Intenses) 100-TW laser facility, require high focusing quality in order to reach up to 10^{21} W.cm^{-2} peak intensity. Managing wave front aberrations is crucial to concentrate as much energy in the smallest spot possible. Moreover the focal spot should be reproducible so that physics experiments could also be reproducible. For any of the high energy CPA facilities in the world, these requirements cannot be fulfilled for full power shots. First, thermal effects induced by optical pumping at high energy as well as the aberrations brought by the optical components, including the large aperture gratings, deform the pulse wave front. Second, as soon as one desires to shoot at a high repetition rate, cumulative thermal effects will increase temperature and strain in amplifiers materials at each shot. In this case, shots are not reproducible whereas the focusing quality decrease from one shot to another.

At LULI, we tried two devices in order to correct full power shots : an electro-optical valve [1] and a deformable mirror (DM) [2]. This paper deals with the second solution. Since fluence at the output of the laser chain is 600 mJ.cm^{-2} at 750 ps pulse duration (30 J in a 80 mm aperture), we used a dielectric coated DM in order to prevent any laser-induced damage. In order to get the highest focusing quality, the DM should be placed as close as possible to the focusing optics. In a CPA laser chain, this means between the compressor last grating and the focusing parabola, i.e. in vacuum. To avoid risks of electrical breakdown in vacuum due to the high voltages applied on the electrodes, the DM was alternatively placed at 0° incidence as a replacement of the mirror enabling double-pass in the final slab-amplifier (see Fig.1).

We measured the wave front with a three wave shearing interferometer (ATWLSI) [3] at two different locations : at the end of the amplifying chain and after compression. Both were used as input for our adaptive optic loop, enabling us to compare their potential to improve the focal spot quality in the target chamber. The first interferometer imaged the deformable mirror plane, whereas the second one imaged a plane within the compressor. Though the second one did not image the deformable mirror plane, we still obtained very stable convergences. After compression, the beam, attenuated to avoid non-linear effects in glass, was focused by a long focal (f=1200 mm) lens.

We compared non-corrected and corrected shots (see Fig. 2) for a sequence of 30 J shots every 20 minutes. In the first case, aberrations grow from one shot to another due to cumulative heat in the slab-amplifier. In the second case, we converged to a flat phase just before each shot and froze the voltages on the mirror during the shot itself. This resulted in reproducible diffraction-limited focal spots for any full power shot in a series (see Fig. 3). We estimated an increase of a factor 4 on the peak intensity from a non-corrected shot to a corrected shot. This means that with our f/15 focusing lens we could obtain intensities above 10^{20} W.cm^{-2}. Future physics experiments will use this device with a f/3 off-axis parabola, allowing intensities above 10^{21} W.cm^{-2}.

Concepts developed for this project will be applied to the LULI Petawatt project currently under construction.

References

[1] B. Wattellier, J. C. Chanteloup, J. Fuchs, et al., CLEO 2001 Technical Digest, 70 (2001).
[2] A. V. Kudryashov and V. I. Shmalhausen, Optical Engineering **30**, 2663 (1996).
[3] J. C. Chanteloup, F. Druon, M. Nantel, et al., Optics Letters **23**, 621 (1998).

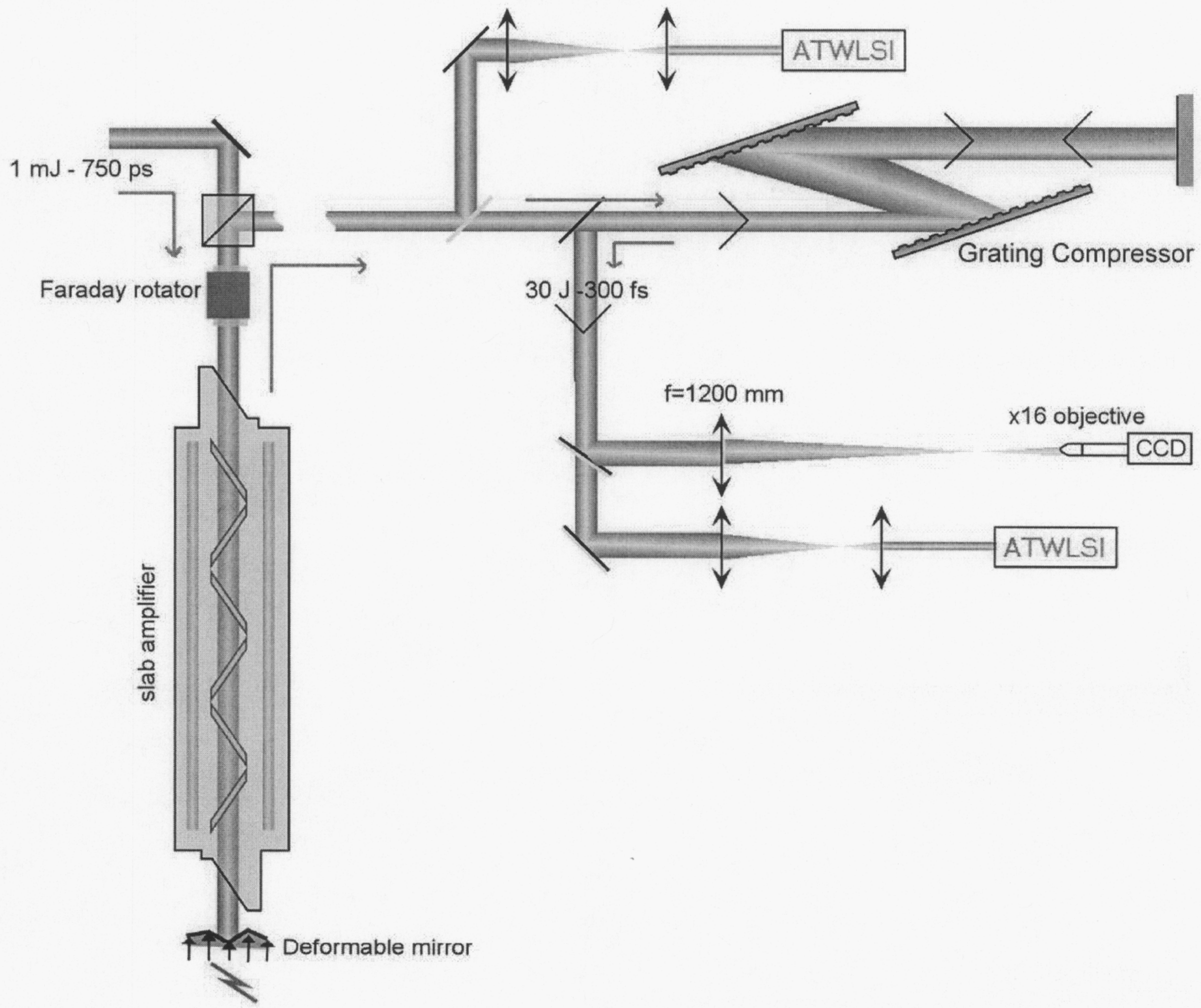

Fig. 1 – Experimental set-up

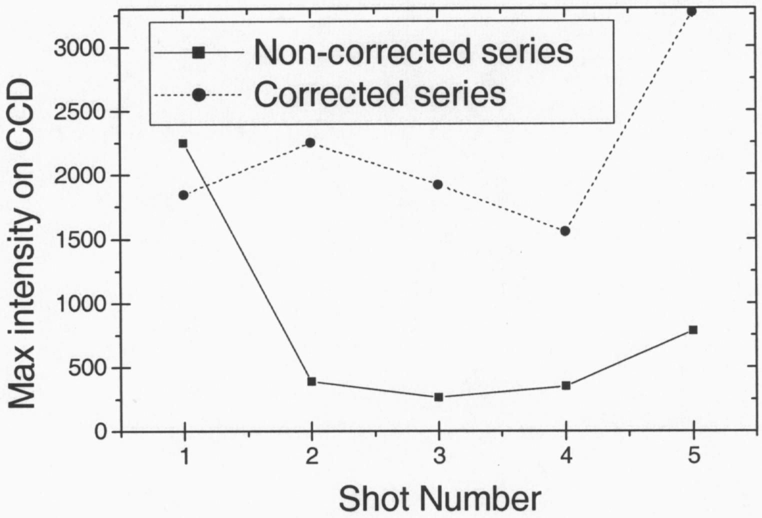

Fig. 2 – Evolution of maximum intensity on the CCD recording the far-field patterns vs. shot number. This value is proportional to the maximum intensity in the focal plane. An average gain of 4 on peak intensity is observed from non-corrected shots to corrected shots.

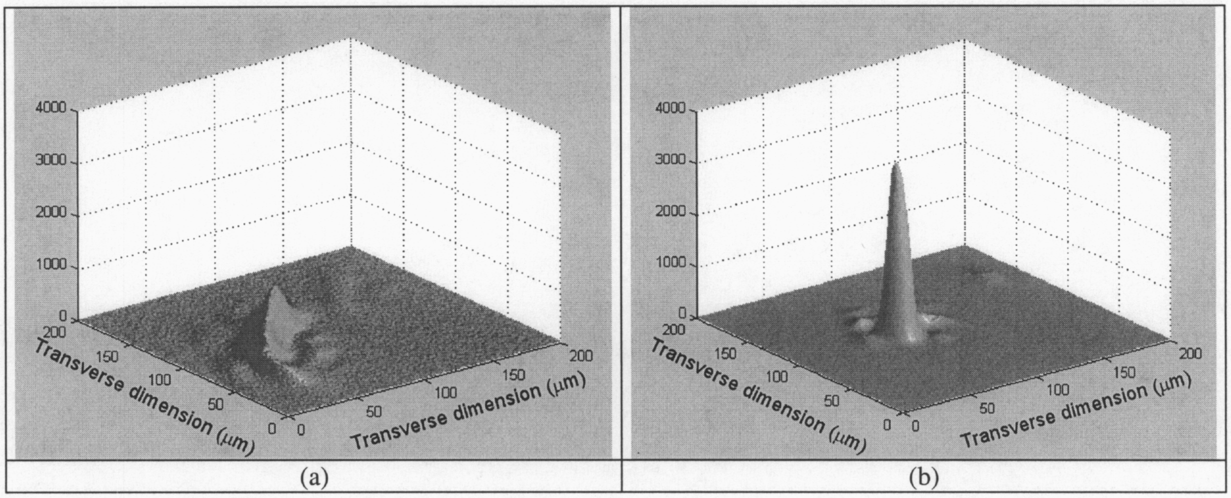

Fig. 3 – Examples of far-field patterns : (a) non-corrected shot #5 - (b) corrected shot #5